9. DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS

The introduction of this section discusses the overall scope, format, and content of the Operable Unit (OU) 4-13 feasibility study (FS) report, including assumptions used in preparing the report. Section 9.1 introduces the format of the comprehensive FS and the screening and disposition of OU 4-13 sites of concern. Section 9.2 lists assumptions developed in scoping the OU 4-13 FS. Section 9.3 presents the development of remedial action objectives (RAOs), identifies contaminants of concern (COCs) and media and exposure pathways of concern, and identifies potentially applicable or relevant and appropriate requirements (ARARs). Section 9.4 presents the development of remedial alternatives. Individual remedial technologies are identified and screened in Section 9.5.

9.1 Site Screening Process

This FS is comprehensive, in that remedies are identified for all sources of contamination at Waste Area Group (WAG) 4 that exceed the allowable risk range. Table 9-1 identifies soil release sites determined to present cumulative human health risks greater than 1E-04 and/or a hazard index (HI) greater than 1, respectively, for one or more exposure scenarios; and/or that contain maximum lead concentrations in soil greater than 400 mg/kg; and/or soil release sites with an ecological risk hazard quotient (HQ) greater than 10.0, for which maximum ecological COC concentrations are greater than 10 times background concentrations. The Central Facilities Area (CFA)-04 pond, the CFA-08 Sewage Treatment Plant and Drainfield, and the CFA-10 Transformer Yard Oil Spills are the only soil release sites with risks, HIs, or lead levels exceeding human health criteria. Three other sites also had cumulative human health risks greater than 1E-04 and/or a hazard index greater than 1; namely CFA-12, -13 and –15. However, since previous remedial actions occurred at these sites that has rendered the exposure pathway incomplete (i.e., the site was excavated during remediation and was covered with clean backfill), these sites were screened from further consideration as human health risks.

Hazard indices for the future residential scenario at CFA-04 are 80.0 and 2.0 for homegrown produce ingestion and soil ingestion, respectively. Mercury is the only human health COC. Human health risks for the future residential scenario at CFA-08 are 4E-04 due to external radiation exposure to Cs-137. Lead concentrations at CFA-10 exceed EPA's screening level.

The Tables in section 3 of Appendix K of the OU 4-13 RI/BRA identify soil release sites determined to present ecological risks greater than a HQ of 10.0. The procedure for ecological risk assessment (ERA) evaluated all the Federal Facility Agreement and Consent Order (FFA/CO) sites and determined that 15 release sites have a potential source of contamination and/or a pathway to ecological receptors. These sites were evaluated using the general approach as discussed in Section 7 of the RI/BRA. The results of the ERA evaluation of the remaining sites are presented as a range of HQs calculated for functional groups present as listed in Section 7. Due to the uncertainty in the ERA methods, HQs are used only as an indicator of risk and should not be interpreted as a final indicator of actual adverse effects to ecological receptors. An evaluation of these results presented in Section 7.4 of the RI/BRA report determined that sites CFA—01, -02, -04, -05, -06, -08, -10, -13, -17/47, -21, -26, -40, -41, -43 and -51 potentially present significant risks to ecological receptors.

A HQ of 10.0 was used for screening ecological risk sites to be addressed in the FS, based on discussions with regulatory agencies. Sites CFA—17/47, -21, -26, -40 and -51 were screened from further consideration as ecological risk on this basis. Additionally, maximum reported

Table 9-1. The WAG 4 human health risk soil release sites of concern retained after BRA screening[a].

Group/Site	Exposure Scenario	Pathway	COPCs	Excess Cancer Risk/HI	Total
CFA-10	0-year occupational	NA	Pb	NA	NA
	100-year residential	NA	Pb	NA	**Pb levels exceed residential PRG**
CFA-04 Pond	0-year occupational	Soil ingestion	As Hg	2E-06 7E-01 (HI)	2E-06 7E-01 (HI)
		Dermal absorption	As	1E-06	1E-06
		External radiation exposure	U-238	1E-06	1E-06
	Total for scenario				5E-06 7E-01 (HI)
	100-year occupational	Soil ingestion	As Hg	2E-06 7E-01 (HI)	2E-06 7E-01 (HI)
		Dermal absorption	As	1E-06	1E-06
		External radiation exposure	U-238	1E-06	1E-06
	Total for scenario				5E-06 7E-01 (HI)
	100-year residential	Soil ingestion	As Hg	3E-05 1E-01 (HI) 1E+00 (HI)	3E-05 2E+00 (HI)
		Dermal absorption	As	5E-06	5E-06
		Homegrown produce ingestion	As Hg	3E-06 8E+01 (HI)	3E-06 8E+01 (HI)
		External radiation exposure	U-238	5E-06	5E-06
	Total for scenario				4E-05 **8E+01 (HI)**

Table 9-1. (continued).

Group/Site	Exposure Scenario	Pathway	COPCs	Excess Cancer Risk/HI	Total
CFA-08: Sewage Treatment Plant Drainfield	0-year occupational	Soil ingestion	Cs-137	1E-06	2E-06
		External radiation exposure	Cs-137	2E-03	2E-03
	Total for scenario				**2E-03**
	100-year occupational	External radiation exposure	Cs-137	2E-04	2E-04
	Total for scenario				**2E-04**
	100-year residential	Homegrown produce ingestion	Cs-137	4E-05	4E-05
		External radiation exposure	Cs-137	4E-04	4E-04
	Total for scenario				**4E-04**

a. Risks and HIs contributing to cumulative risks greater than 1E-06 and/or cumulative HIs greater than 1.0 only are shown.

ecological COC concentrations less than 10 times background concentrations were screened from further consideration. Site CFA-06 was eliminated as ecological risk on this basis. Ecological risk sites of concern retained after screening include CFA—01, -02, -04, -05, -10, -13, -41 and -43. The WAG 4 environmental COCs in soil include copper, lead, and mercury.

9.2 Assumptions

Several assumptions were developed to facilitate preparation of this FS. These assumptions were developed in conference calls with the Idaho Department of Health and Welfare (IDHW), U.S. Environmental Protection Agency (EPA) Region 10, and U.S. Department of Energy Idaho Operations Office (DOE-ID) in February 1998 and are listed below.

9.2.1 General Assumptions

The general assumptions include:

1. The *Long-Term Land Use Future Scenarios for the INEL* (DOE 1995a) document identified the role of the CFA for the next 100 years as the "primary technical service and support area." The CFA is therefore assumed to be institutionally controlled for that time, including access restrictions and other administrative and physical security controls. These types of controls on physical access are assumed to end in 2095.

2. Groundwater contamination that may enter WAG 4 from upgradient sources will be addressed by the WAG from which the contaminant plume originated.

3. In the event that currently unknown contaminant releases are encountered at OU 4-13 in the future, the investigation and remedial response will be required to meet OU 4-13 FS RAOs. This will be stated in the OU 4-13 Record of Decision (ROD).

4. It is assumed that current or future facilities and operations at CFA will not interfere with remedial activities. Remediation of any site of concern could begin within 15 months after signature of the ROD.

5. Innovative technologies will be evaluated in this FS only if they have been successfully demonstrated at pilot-scale or greater, for contaminants and media similar to those found at OU 4-13.

6. A soil repository (the Idaho National Engineering and Environmental Laboratory [INEEL] Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Disposal Facility or ICDF) is assumed to be available on the INEEL, south of the Idaho Nuclear Technology and Engineering Center (INTEC), by 2001. This facility will be permitted to receive essentially any contaminated soil generated on the INEEL, including mixed wastes. Disposal capacity for Resource Conservation and Recovery Act (RCRA) hazardous or mixed waste soils is assumed to exist at this facility by 2002. Excavation and disposal of WAG 4 soils would be coordinated with ICDF operations to allow for use of this disposal option.

9.2.2 Assumptions for RAO Development

The assumptions for the RAO development include:

1. Soil contaminants are defined as COCs if, either singly or cumulatively, they currently result in, or are predicted to result in the future, an excess cancer risk of greater than 1E-04, and/or a HI greater than 1.0. This does not include naturally occurring elements and compounds not attributable to an OU 4-13 release.

2. The RAOs for soil will be defined by COC and exposure pathway.

3. Soil release site RAOs would be met everywhere within the extent of soil contamination resulting from WAG 4 sources.

4. Ecological risks are assumed to be reduced by active remedial measures implemented to reduce human health risks, for those sites presenting risks to both. Ecological risks will be reevaluated in the WAG 10 comprehensive ERA to determine if the actions are truly protective of ecological receptors.

5. Ecological risk sites with HQs >1 were screened. Those with HQs greater than 10.0 and for which maximum COC concentrations are at least 10 times background concentrations are evaluated in this FS. Both screening levels were proposed by EPA Region 10[a] based on the "conservative" nature of the ERA, and were accepted by DOE-ID and the IDHW.

6. EPA's screening level soil lead concentration of 400 mg/kg will be used as a human-health preliminary remediation goal (PRG).

9.3 Remedial Action Objectives

Remedial action objectives for OU 4-13 were developed in accordance with the NCP and CERCLA RI/FS guidance, and were refined through discussions among agencies (IDHW, EPA Region 10, and DOE-ID). The RAOs are based on the results of both the human health and ecological risk assessments and are specific to the COCs and exposure pathways developed for OU 4-13.

The RAOs specified for protecting human health are expressed both in terms of risk levels and exposure pathways, because protection can be achieved by reducing contaminant levels, as well as by limiting or eliminating exposure pathways. The RAOs specified for protecting the environment are intended to preserve and/or restore the resource.

The OU 4-13 BRA evaluated current and future occupational and residential use scenarios (post-2095). According to the *Long-Term Land Use Future Scenarios for the INEL* (DOE 1995a) document the INEEL is assumed to remain under government management for at least 100 years from 1995, and the CFA will remain a restricted-access industrial use site.

Current onsite workers, hypothetical future workers and residents, and ecological receptors were considered in developing the RAOs. The RAOs cited below would be met within the boundary of each soil release site requiring remedial action, which is defined as the areal extent of COCs resulting in cumulative human health risks greater than 1E-04, and/or a cumulative human health HI greater than 1.0, for either the occupational or future residential scenarios, via any soil exposure pathway; and/or ecological risks greater than a HQ of 10.0. The RAOs for ecological risk may be revised, after completion of the WAG 10 INEEL-wide ERA.

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a. Conference call on 2/9/98 with EPA Region 10, DOE-ID, and the IDHW.

Based on the preceding discussion, the following OU 4-13 RAOs have been developed to protect human health and the environment:

For Current and Future Workers and Future Residents, Due to Risks Presented by Contaminated Soils

- Inhibit direct exposure to radionuclide COCs, at any OU 4-13 soil release site, that would result in a total excess cancer risk for the site greater than 1E-04.

- Inhibit ingestion of radionuclide and non-radionuclide COCs, at any OU 4-13 soil release site, by all soil exposure routes (including soil ingestion, inhalation and homegrown produce ingestion), that would result in a total excess cancer risk for the site greater than 1E-04, or a total HI greater than 1.0. This does not include lead, for which no carcinogenic slope factors or RfDs are available.

For Inhibiting Degradation of Sites where COCs Remain in Soil

- Inhibit degradation of final covers where wastes remain in place that would result in exposure to, or migration to the surface of, COCs that would result in total excess cancer risk for the site greater than 1E-04, or a total HI greater than 1.0, to current and future workers and to future residents.

For Protection of the Environment

- Inhibit ecological receptor exposures to contaminated soils resulting in a HQ greater than 10.0, where COC concentrations are at least 10 times background concentrations, as determined by the ecological risk evaluation. This does not include naturally occurring elements and compounds not attributable to OU 4-13 releases.

9.3.1 Contaminants and Sites of Concern

Contaminants of potential concern (COPCs) for human health risks identified in the RI/BRA for OU 4-13 sites of concern are summarized in Table 9-1. A final set of COCs were developed by identifying COPCs resulting in, either individually or cumulatively, site risks greater than or equal to 1E-04 and/or HIs greater than or equal to 1.0, as determined in the BRA for all exposure scenarios considered. Lead present at concentrations greater than 400 mg/kg is also defined as a COC. The OU 4-13 human health risk soils COCs include Pb, Hg, and Cs-137. No groundwater COCs were identified.

The RCRA characterization performed in 1998 determined that a fraction of CFA-04 soils are RCRA toxicity characteristic wastes for mercury (D009), and that a fraction of CFA-10 soils are RCRA toxicity characteristic wastes for lead (D008).

Sites of concern are those sites with cumulative risks greater than 1E-04, a cumulative HI greater than 1.0 and/or lead concentrations greater than 400 mg/kg. The OU 4-13 sites with cumulative risks greater than 1E-04 and/or with HIs greater than 1.0 are also shown in Table 9-1.

Contaminants and sites of concern for ecological risks are discussed in Section 7 of the RI/BRA Report, and are listed in Tables K-1 through K-13 in Appendix K. Ecological risk COCs are those resulting in ecological risks greater than a HQ of 1.0, and for which maximum concentrations are greater than 10 times INEEL background soil concentrations. Ecological risk sites of concern for screening purposes, are defined as those with HQs greater than 10.0 and for which COC maximum concentrations are at least 10 times background concentrations.

9.3.2 Media and Materials of Concern

Media and materials of concern for CFA-10 consist almost entirely of contaminated soils. Minor amounts of debris are present at CFA-04, primarily buried in the sides of the pond, including asbestos roofing material and other roofing debris. A 122 m (400 ft), 15-cm (6-in.) diameter drain line supplies the pond; however, this line will be addressed by the decontamination and dismantlement (D&D) program. At CFA-10, a concrete pad 6 m (20 ft) wide extends approximately 18 m (60 ft) across the width of the yard.

The CFA-08 drainfield contains approximately 12,192 m (40,000 ft) of gravel-filled trenches containing clay drainage tiles, supplied by concrete feeder pipes from the concrete diversion boxes. Individual elements are described below.

9.3.2.1 Drain Tiles. There are five drainfield areas each with 20, 61-m (200-ft) lines. Total length of drain tiles is 6,096 m (20,000 ft). Each drain tile section is 10-cm (4-in.) diameter red clay pipe in 1.2-m (4-ft) length sections, with a wall thickness of 2.5 cm (1 in.), laid with a 2.5-cm (1-in.) gap between ends. The drain tiles are 0.6 m (2 ft) below ground surface (bgs). Each line was installed in a trench, 0.8 m wide × 2.4 m deep (2.5 ft wide × 8 ft deep), filled with screened sewer gravel. The top 30 to 46 cm (12 to 18 in.) were backfilled with excavated soil. Some tile sections likely contain low level radioactive sludge.

9.3.2.2 Feeder Pipes. A 20-cm (8-in.) diameter concrete feeder line approximately 2.4 m (8 ft) bgs runs parallel to the drainfield for approximately 244 m (800 ft) and supplies the diversion boxes. It is reportedly 1/3 filled with nonhazardous (samples from the sludge were collected and analyzed for toxicity characteristic leaching procedure [TCLP] during the RI/FS) low level radioactive sludge.

Two 10-cm (4-in.) cast iron feeder lines also run parallel to the drainfield. The total length of 10-cm (4-in.) pipe is 274 m (900 ft). It is reportedly filled with nonhazardous low-level radioactive sludge.

9.3.2.3 Concrete Diversion Boxes. Five concrete diversion boxes with 20-cm (8-in.) thick walls and a wood top supply the drain tiles. The inside dimension of each box is 0.6 x 0.6 m (2 × 2 ft). The height is between 0.9 and 1.5 m (3 and 5 ft). There is a metal headgate inside each box. The boxes reportedly contain less than 0.3 m (1 ft) of sludge.

9.3.3 Contaminated Site Dimensions

Approximate dimensions of contaminated sites are shown in Table 9-2. Depths of remediation shown are conservative estimates, based on deepest detections reported, on estimated contaminant mobility, and the lack of human health exposure pathways for contaminants deeper than 3.0 m (10 ft) bgs.

For CFA-10 only four samples were collected for Pb analysis, and all came from the surface. In the absence of subsurface data, and based on the K_d of 100 and infiltration rate of 10 cm/year (4 in./year), both suggested in DOE (1994); and on an assumed bulk density of 1.65 and a porosity of 0.25, this would result in a retardation coefficient of 661 and a Pb transport velocity of 1.5E-02 cm/year (4.9E-04 in./year).

Table 9-2. COCs and remediation dimensions for OU 4-13 sites of concern.

Site	Human Health COCs	Ecological Risk COCs	Maximum Depth of Remediation m (ft) bgs	Area m^2 (ft^2)	Volume m^3 (ft^3)
CFA-04: Disposal Pond at CFA-674	Hg	Cu, Hg	2.13–3.05 (7–10)	6.88E+03 (7.43E+04)	6.29E+03 (2.23E+05)
CFA-08: Sewage Treatment Plant Drainfield	Cs-137	NA	0–3.05 (0–10)	1.85E+04 (2.00E+05)	5.64E+04 (2.00E+06)
CFA-10: Transformer Yard Oil Spills	Pb	Pb	0–0.15 (0–0.5)	8.08E+02 (8.70E+03)	1.23E+02 (4.35E+03)

NA = Not Applicable (no risk).

Using these transport parameters, it would take over 2E+03 years for Pb to travel 0.3 m (1.0 ft). Lead contamination resulting from surface releases at all sites was therefore assumed to be confined to the top 0.15 m (0.5 ft) of soil.

The average depth of the CFA-04 pond is 2.13 m (7 ft) bgs. For mercury contamination at CFA-04 it was determined that soils are contaminated above PRGs to a depth of at least 0.9 m (3.0 ft) below the bottom of the pond (3 m [10 ft] bgs), based on July 1998 sampling data provided in Appendix B. The actual depth of contamination is unknown; however, remediation to a depth of 3 m (10 ft) bgs (i.e., 0.9 m [3.0 ft] below the bottom of the pond) would eliminate human health and ecological exposure pathways, assuming the pond would be backfilled as part of any remedy. Based on the July 1998 sampling, approximately 467 m^3 (611 yd^3) of soil in the pond are estimated to be RCRA toxicity characteristic wastes for mercury (D009).

The CFA-04 site includes a windblown area of mercury contamination outside the pond, with contamination above PRGs, as shown in Figure 3-1. The depth of contamination is assumed to not exceed 0.15 m (0.5 ft) bgs. The estimated total windblown area and volume are 682 m^2 (1,686 ft^2) and 645 m^3 (843 yd^3), respectively. Based on the July 1998 sampling, approximately 141 m^3 (185 yd^3) of the windblown soils are estimated to be RCRA toxicity characteristic wastes for mercury (D009).

Contamination at the CFA-08 Sewage Treatment Plant drainfield was assumed to extend to 3 m (10 ft) bgs for purposes of identifying remedial alternatives, based on Cs-137 detection above the PRG at depths of 1.2 to 2.4 m (4 to 8 ft) bgs; and on the depth of the trenches (2.4 m [8 ft] bgs) containing the drain tiles. The maximum depth of remediation is based on maximum depth of soil contamination that could result in receptor exposures above allowable levels, as defined in the RI/BRA.

9.3.4 Exposure Pathways of Concern

Human health exposure pathways of concern identified in the OU 4-13 BRA are those resulting in risks greater than 1E-06 and/or HIs greater than 0.1, and are listed in Table 9-1. The cumulative HI for CFA-04 exceeds the allowable range for the residential 100-year scenario, primarily due to ingestion of mercury-contaminated homegrown produce. Cumulative risks at CFA-08 exceed the allowable range for the 0-year occupational scenarios, and for the 100-year residential scenario, due to external Cs-137 exposure. Lead concentrations in soil at CFA-10 exceed the 400 mg/kg EPA screening level.

Ecological risks at OU 4-13 sites are summarized in Tables K1 through K13 in Appendix K of the RI/BRA. Sites with HIs greater than 10.0 for ecological receptors, and for which COC concentrations are greater than 10 times background concentrations, are listed in Table 9-2.

Current administrative controls implemented under DOE Order 5480.11 require that worker radiological exposures be as low as reasonably achievable (ALARA). Worker risks identified in the BRA were estimated assuming no administrative or engineering controls; however, ALARA controls reduce occupational risks to allowable levels at all sites. Under ALARA, radiation control fences are maintained to restrict worker access, the safe work permit process defines administrative and engineering controls on exposures for workers entering the areas, and monitoring by radiological control technicians during work in radiation control areas limit exposures. These activities will be maintained during the 100-year institutional control period at all WAG 4 sites, reducing radiological risks to workers to allowable levels.

9.3.5 Preliminary Remediation Goals

The PRGs are quantitative cleanup levels, based primarily on ARARs and risk-specific doses (EPA 1988). The PRGs are used in planning remedial actions and assessing effectiveness of remedial alternatives. Final remediation goals are based on results of the BRA, and evaluations of expected exposures and risks for alternatives, and consider the effects of multiple contaminants. The OU 4-13 ROD will present final remediation goals.

The 1E-04 risk or HI equal to 1 level, which ever is more restrictive for a given contaminant, is the basis for determining PRGs for OU 4-13. Therefore, PRGs for individual COCs were defined by calculating soil concentrations that would result in excess cancer risks equal to 1E-04, or health risks resulting in a HI equal to 1, for hypothetical residents present at the end of the 100-year institutional control period, summed for all pathways and all COCs present at each site. A given COC may have different PRG values at different sites, because some sites have more COCs than others do. For example, if a given site has only one COC requiring remediation, the PRG would equal the contaminants risk of 1E-04 or HI of 1 residential risk-based concentration. If, however, the site has two COCs requiring remediation, the PRG for each would equal the risk of 5E-05 or HI of 0.5 concentration for each COC, so that the total risk for the sites would equal 1E-04 ($2 \times$ 5E-05 = 1E-04), or the total HI for the site would equal 1.0 ($2 \times 0.5 = 1.0$). This analysis method assures that each contaminant would have to be remediated to the same risk level in order to achieve an acceptable risk for the site. The PRGs calculated for OU 4-13 sites are provided in Table 9-3.

Table 9-3. PRGs for OU 4-13 sites.

Site	Contaminant		PRG[a] (pCi/g or mg/kg)
CFA-04	**Human health:**	Hg	1.27
	Ecological:	Cu	3.2E+02
		Hg	7.4E-01
CFA-08	**Human health:**	Cs-137	2.3E+01
	Ecological:	NA	
CFA-10	**Human health:**	Pb	4.0E+02
	Ecological:	Pb	2.3E+02

a. Ecological risk PRGs for all COCs = 10X background concentrations reported in Section 7 of the RI/BRA report.

A PRG for lead in soils was developed, based on EPA guidance recommending that cleanups at CERCLA sites for residential land use result in lead concentrations not to exceed 400 mg/kg (EPA 1994). The 400 mg/kg level was determined using the EPA Uptake Biokinetic Model to predict blood lead levels in children, the most sensitive segment of the potentially exposed population. Lead has not been demonstrated to be a carcinogen in humans or animals, and no slope factors have been determined.

9.4 Identification of Alternatives

9.4.1 General Response Actions

General Response Actions (GRAs) are broad categories of remedial actions that will satisfy RAOs for the contaminated media at OU 4-13 sites. In order to protect human health and the environment, the intent of GRAs is to eliminate source-to-receptor pathways by preventing external exposure to and direct contact with contaminants, and by reducing or eliminating contaminant migration to clean media or to biota. Soil, sediments, concrete and tile pipe, gravel and debris are the contaminated materials potentially targeted for remediation at the OU 4-13 sites.

The GRAs, individually or in combination with other GRAs, can satisfy RAOs in one of two ways: (1) contaminants can be destroyed or reduced in concentration to levels posing acceptable risks to human health and the environment or (2) contaminants can be isolated from potential exposure and migration pathways to decrease risks to human health and the environment. Contaminant destruction is the preferred method because it ensures that RAOs have been satisfied. However, radionuclide and toxic metal contamination within the OU 4-13 sites cannot be destroyed and must therefore be reduced in concentration or isolated from potential exposure and migration pathways.

A range of GRAs and combinations of GRAs that could achieve varying degrees of protectiveness of human health and the environment, and compliance with RAOs, were defined. Six GRAs and combinations of GRAs identified for contaminated media at OU 4-13 sites include:

- No action (with monitoring)
- Institutional controls
- Containment and institutional controls
- Removal and disposal and institutional controls
- Removal, treatment ex situ, disposal and institutional controls
- Treatment in situ and institutional controls.

A brief description of each GRA identified for the OU 4-13 sites is presented below.

9.4.1.1 No Action with Monitoring. The no action with monitoring GRA does not involve active remedial actions with the exception of environmental monitoring. Monitoring would serve to identify potential contaminant migration or other potential changes in site conditions that may warrant future remedial actions. Types of environmental monitoring considered for use at the OU 4-13 sites are defined in the description of alternatives presented in Section 9.5. Monitoring is an institutional action that can be assumed to remain in effect for at least 100 years.

9.4.1.2 Institutional Controls. Institutional controls refer to actions taken by responsible authorities to minimize potential danger to human health and the environment. Institutional controls include ongoing actions that can be maintained only as long as the responsible authority is in control of the site; as well as deed restrictions that limit land use after transfer from the responsible authority. In order to remain consistent with the BRA (Section 6), the 100-year institutional control period is assumed to begin in 1998.

Long-term environmental monitoring, as for the No Action With Monitoring alternative; access restrictions, including fencing, deed restrictions and other measures; and surface water diversion would be established and maintained as necessary where contamination remains in place to provide early detection of potential contaminant migration and to control exposures to contaminants. These programs would be implemented annually for the first 5 years following signature of the ROD. The need for further institutional controls would be evaluated and determined by the Agencies during subsequent 5-year reviews, which are required under 40 CFR 400.430(f)(4)(ii) at sites where contaminants remain above levels that allow for unrestricted use.

9.4.1.3 Containment and Institutional Controls. This GRA utilizes a combination of containment actions and institutional controls. Containment refers to remedial actions taken to isolate contamination from the accessible environment, and for soil release sites typically includes capping. Institutional controls are described in Section 9.4.1.2 above. Isolating contaminants of concern would eliminate potential exposure pathways to human or environmental receptors, however institutional controls, described previously, are assumed to be required to ensure effectiveness wherever contaminants remain in place above PRGs. Five-year reviews would ensure continued effectiveness of the remedy.

9.4.1.4 Removal and Disposal. This GRA involves complete removal of material contaminated at concentrations greater than PRGs from the sites, followed by disposal at an appropriate location. Monitoring and/or institutional controls would not be required where all contamination above allowable levels was removed. However, if contamination above PRGs remained at the site, institutional controls would be required to monitor and maintain the effectiveness of this remedy. At a minimum, these would include 5-year reviews and deed restrictions.

9.4.1.5 Removal, Treatment Ex Situ, and Disposal. This GRA consists of excavating contaminated soils and debris and treating them to reduce the toxicity, mobility, and/or volume of the contamination. Treatment would be required for all RCRA LDR wastes excavated and removed from the AOC.

No method exists for destroying radionuclide contaminants or reducing their toxicity. However, volumes of contaminated media may be reduced and some toxic metals may be rendered less toxic through treatment. Previous actions at similar sites, including removal actions at WAG 4, were reviewed to identify and screen treatment technologies potentially effective at OU 4-13.

Monitoring and/or institutional controls would not be required where all contamination above allowable levels was removed. However, if contamination above PRGs remained at the site, institutional controls would be required to monitor and maintain the effectiveness of this remedy. At a minimum, these would include 5-year reviews and deed restrictions.

9.4.1.6 Treatment In Situ. This GRA consists of implementing technologies capable of immobilizing or reducing the toxicity or volume of contaminants in situ. No method exists for destroying radionuclide contaminants or reducing their toxicity. However, volumes of contaminated media may be reduced, and some toxic metals may be rendered less toxic through in situ treatment. Previous actions at similar sites were reviewed to identify and screen treatment technologies potentially effective at OU 4-13.

Institutional controls would be required where contamination remains in place above PRGs, as described previously.

9.5 Identification and Screening of Technologies

This section discusses the methods used to identify remedial technologies and process options representative of the GRAs described previously. Treatment process options demonstrated at similar sites, and/or results of INEEL treatability studies, were reviewed to identify and screen treatment process options potentially effective at OU 4-13. Technologies and response actions demonstrated to be effective for sites with similar contaminants and contaminated media types, and in particular those demonstrated at the INEEL, are used to define applicable process options and technology types. Innovative and emerging technologies that have been demonstrated at least at pilot scale are also considered.

Table 9-4 shows the identification and screening process for remedial technologies at OU 4-13. First, remedial technology types representing each GRA were identified. Then, process options representing each technology type were identified and screened based on effectiveness, implementability, and cost, relative to other processes within the same technology type. Evaluation of effectiveness considers the ability of the technology to handle the types and volumes of contaminated media present, and to meet RAOs; the potential impacts to human health and the environment during implementation; and proven reliability of the technology with respect to contaminants and conditions present at the site.

Evaluation of implementability considers both technical and administrative feasibility of the technology. Technical implementability includes consideration of technology-specific parameters that constrain effective construction and operation of the technology, with respect to site-specific conditions. Administrative implementability includes consideration of ability to obtain required permits for offsite actions; availability of treatment, storage, and disposal services; and the availability of equipment and personnel required to implement the technology.

Evaluation of cost considers relative estimates of capital and operations and maintenance (O&M) costs. Engineering judgement is used to estimate costs as high, moderate, or low, relative to other process options in the same technology type.

Technologies determined not to be effective or implementable for OU 4-13 sites and COCs were screened from further consideration. The technology screening shown in Table 9-4 is summarized below. Process options and technology types are listed under their respective GRAs.

9.5.1 No action With Monitoring

9.5.1.1 Environmental Monitoring. Monitoring would include only soil monitoring, since direct radiation exposure and soil and homegrown produce ingestion were identified as the only exposure pathways of concern in the OU 4-13 BRA. Soil monitoring could include radiation surveys over and around sites where contaminated soil and debris are left in place to determine if radionuclides have been mobilized to the surface, and/or soil sampling and laboratory analysis for toxic metals. Air monitoring would be effective only for monitoring worker exposures during remedial actions. Groundwater monitoring is currently implemented, but costs of continued groundwater monitoring were not included in long-term environmental monitoring, since OU 4-13 soil release sites were not predicted to affect groundwater.

Soil monitoring is technically and administratively implementable. Monitoring alone would not meet RAOs, but may in combination with other GRAs and technologies. Costs of soil monitoring are

Table 9-4. Summary of screening of OU 4-13 remedial technologies.

GRAs	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Result
No action with monitoring	Environmental monitoring	Soil	High, when combined with other options.	High	Low	Retain
		Air	No effectiveness, except for monitoring exposures during remedial actions, since air exposures from OU 4-13 soil release sites were determined to be acceptable.	High	Low	**Reject**
		Groundwater	No effectiveness, since OU 4-13 soil release sites were determined to not affect groundwater.	High, already implemented	Moderate	**Reject**
Institutional controls	Access restrictions	Fences	High, for institutional control period only, and for human health risk reduction only.	High, for institutional control period only	Low	Retain
		Deed restrictions	High, for human health risk reduction only. Assumed to last in perpetuity.	High	Low	Retain
	Maintenance	Cap integrity monitoring and maintenance	High, for institutional control period.	High, for institutional control period	Moderate	Retain
		Surface water diversions	High, for institutional control period.	High, for institutional control period	Moderate	Retain
Excavation	Standard techniques	Backhoes and dozers	High.	High for accessible sites	Low	Retain
	Remote techniques	Robotics	Uncertain-site specific.	Uncertain, site specific	High	**Reject**
Containment	Capping	ET-type	High.	Moderate, high	Moderate	Retain
		SL-1-type	Moderate, does not reduce infiltration.	High	Low-moderate	Retain
		RCRA-type	Moderate.	Moderate	High	Retain

Table 9-4. (continued).

GRAs	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Result
		Native soil	Moderate.	High	Low-moderate	Retain
		Concrete	Moderate.	Moderate	High	Retain
Disposal	Landfilling	RWMC	High.	High, although operations currently discourages low-level rad soil disposal	High-if stated disposal costs are applied	Retain
		ICDF	Status uncertain.	Status uncertain-currently projected to be available in 2001 for LLW soil, 2002 for hazardous-mixed soil	Low	Retain
		INEEL landfill complex	High.	High	Low	Retain
		Offsite MLLW landfill	High.	High	Moderate-High	Retain
		RCRA TSDF	High for RCRA soils, won't accept rad or mixed.	High for RCRA soils, won't accept rad or mixed	High	Retain
		NTS	High.	INEEL not an approved generator	High	**Reject**
Treatment In Situ	Physical-chemical	In situ chemical stabilization	Moderate, no reduction in direct exposure risks; would reduce toxic metal risks.	Low-uncertain; site specific	Moderate	Retain
	Chemical	Soil washing	Low.	Low	High	Retain
	Thermal	ISV	Low-moderate; no reduction in direct radiation exposure risks; would eliminate all other risks.	Low-moderate; technically complex, site specific	High	**Reject**
	Biological	Phytoremediation	Uncertain; currently undergoing testing at ANL-W.	Uncertain	Low	Retain, pending ANL-W test results

Table 9-4. (continued).

GRAs	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Result
Treatment ex situ	Physical	Screening	Uncertain, not demonstrated for WAG 4 soils and COCs; not effective for volume reduction from Cs-137-contaminated INEEL soils in previous tests. May be effective as a pretreatment step for subsequent processes.	High	Low	Retain
		Flotation	Uncertain, not demonstrated for WAG 4 soils and COCs	Moderate-produces secondary wastestream	Moderate	Retain
		Attrition scrubbing	Uncertain, not demonstrated for WAG 4 soils and COCs; not effective for Cs-137 removal from INEEL soils in previous tests	Moderate-produces secondary wastestream	Moderate	Retain
		Segmented gate	Uncertain, potentially high for rad soil sites.	Moderate	Moderate	Retain
	Physical/Chemical	Soil washing	Uncertain, not demonstrated for WAG 4 soils and COCs; not effective for Cs-137 removal from INEEL soils in previous tests.	Low-produces secondary wastestream; site-specific treatability studies required.	Moderate	**Reject**
		Stabilization	Moderate. Would not significantly reduce direct radiation exposure risks, would be effective for toxic metal-contaminated soils.	Moderate	Moderate	Retain
	Thermal	Plasma torch	Moderate. Would not reduce direct radiation exposure risks, may be effective for Pb and Hg contaminated soils.	Low	High	Retain
		Mercury retort	High for Hg only.	Moderate; demonstrated at INEEL; produces secondary wastestreams	High	Retain

relatively low, while groundwater monitoring costs are moderate. For cost estimating purposes, monitoring was assumed to be 100 years; however, this duration is not driven by ARARs and could be reduced with concurrence of the regulatory agencies.

9.5.2 Institutional Controls

Institutional controls alone may meet human health RAOs during the institutional control period and longer if combined with other technologies and GRAs. Representative types of institutional controls are described below.

9.5.2.1 Fences. Access restrictions including fences are assumed to be maintained for at least the 100-year institutional control period following site closure. Fences must be accompanied by warning signs to be effective in controlling exposures to inadvertent intruders. Fences are effective in controlling human exposures by restricting access during the institutional control period, but in general are not effective in reducing ecological exposures. Fences are technically and administratively implementable. Costs are relatively low.

9.5.2.2 Deed Restrictions. Deed restrictions can be implemented if the government-owned property is ever transferred to non-government ownership. Deed restrictions are considered effective in perpetuity, and are implementable through the Record of Decision (EPA 1998). The deed discloses former waste management and disposal activities that occurred at the site, and can restrict future activities at the site through protective covenants and easements. Deed restrictions are not effective in reducing ecological exposures. Costs are relatively low.

9.5.2.3 Cap Integrity Monitoring and Maintenance. This option would apply to sites where wastes were left in place and contained under a final cover. Cover integrity monitoring and maintenance was assumed to be performed for at least the 100-year period of institutional control, to assess the physical condition of the cap, and to determine if corrective actions were required. Monitoring would include visual inspections in combination with the radiation surveys described previously under environmental monitoring to determine if animal burrows, erosion or other processes had damaged the cover or barrier to a degree requiring maintenance. Maintenance would consist of filling burrows, repairing erosion damage and subsidences, and potentially other activities.

The time required for maximum activities of Cs-137 at CFA-08 to decay to the unrestricted release level of 2.3 pCi/g was estimated as 189 years. Any cover or barrier designed for this site would be required to control exposure pathways of concern for at least those durations.

Cap integrity monitoring and maintenance would be effective and implementable for the institutional control period. Costs are estimated to be relatively moderate.

9.5.2.4 Surface Water Diversions. This option would apply to sites where wastes were left in place and contained under a final closure cover. Surface water diversions would most likely consist of maintaining existing drainage ditches and channels by regular inspection and removal of debris. No new construction would be expected to be required except as part of design of other remedial alternatives as explained in subsequent sections. Maintaining surface water diversions would be effective and implementable for the institutional control period. Costs are estimated to be moderate.